Chapter 1

A Systems Approach to Cross–Content Workplace Readiness

Preface

According to Robert Reich, former U.S. Secretary of Labor in *The Work of Nations*, the current U.S. educational system is based on an industrial model of production and an eighteenth-century model of knowledge compartmentalized into discrete disciplines. This instills a mental model in students that the world is made up of discrete components, each capable of being understood in isolation. Most formal education perpetuates a fallacy of compartmentalizing systems, offering up facts and figures in bite-size units of social studies, language, mathematics, and science, as if each were distinct and unrelated to the others. To discover new opportunities, one must be capable of seeing the whole and understanding the processes by which parts of reality are linked together. Issues in the real world rarely emerge in a predefined, neatly separable way.

As society becomes more complex, traditional education becomes less relevant because of its fragmentary nature. A more effective and engaging approach to educating can be found in the combination of *integrated instruction* and *a systems approach*. The result is a highly motivating and engaging frame for learning. Such an approach encompasses experiential education, through which students learn by the following means: by doing, by helping to select and design projects, by researching possible solutions from a wide variety of resources, by presenting their work to outside review panels, and, finally, by evaluating their work on their own terms. Academic content is integrated into all of these activities so that students' education is structured to meet the requirements of the standards. The intent of this framework is to demonstrate a path to bring these ideas to fruition.

Systems and Systems Thinking: How Things Really Work

A **system** is an arrangement of interacting, interrelated, or interdependent parts, rules, and principles designed to be unified to work as a whole – for example, the solar system; a political system; a system of government; office systems; a method, plan, or process; a mechanized or electronic system. All the parts of the system are related to the same overall process, procedure, or structure, yet they are (most likely) different from one another and often perform completely different functions.

Systems thinking is defined as a way of thinking about, as well as a language for describing and understanding, the forces and interrelationships that shape the behavior of systems. Systems thinking helps us change systems more effectively, and act in tune with the larger processes of the natural and economic world. It articulates the interrelationships of the complex elements of real-life situations as they evolve over time.

Complex systems include all or some of the following characteristics:
- self-stabilizing
- goal-seeking
- program-following
- self-reprogramming
- environment-modifying
- self-replicating
- self-maintaining and repairing
- self-reorganizing
- self-programming

Complex systems often exhibit behaviors that include anticipating changes in the environment, inertia or initial resistance to change. Since education is a complex system, the framework presented here is a step forward in a journey that will take time.

Design: The Creativity of Work

Design is the fusion of imagination and action. It is defined by the following characteristics or attributes (International Technology Education Association, 2000):
- purposeful in intent
- based on certain functional, constraining, schedule, or cost requirements
- systematic in approach or processes used to accomplish the design
- creative
- many possible solutions

Design becomes a context for learning. It allows students to apply content-area concepts and skills. A design and problem-solving approach emphasizes students' active participation. They are asked to make deliberate choices, to think critically about problems, and then to act by designing and implementing potential solutions. These are transferable skills that support life-long learning and problem solving.

The actual thought processes used in design will vary from person to person and will differ with varying contexts. Therefore, a global design process cannot be modeled with complete accuracy. Any design process is merely a generic guide that assists students through the many phases of designing.

A simple design process includes the following steps: analysis, synthesis, and evaluation. Teachers will need to break down these steps according to the developmental levels of the learners. Opposite are the steps in models for elementary and high school levels.

Elementary Level:
- ▶ What is the problem?
- ▶ Think of some solutions (brainstorm).
- ▶ Select a possible solution.
- ▶ Implement and test the solution.

High School Level:
- ▶ Analyze and investigate a real-world situation.
- ▶ Frame a design brief.
- ▶ Gather information.
- ▶ Generate alternative solutions.
- ▶ Choose a solution.
- ▶ Conduct developmental work.
- ▶ Produce a prototype.
- ▶ Test and evaluate the prototype.
- ▶ Redesign and re-implement the solution.

One cannot design effectively without an understanding of systems and the application of systems thinking in the design process. Figure 1.1 shows the relationship between design and systems thinking.

Figure 1.1
DESIGN AND SYSTEMS THINKING

How do I find out?   *How does this work?*
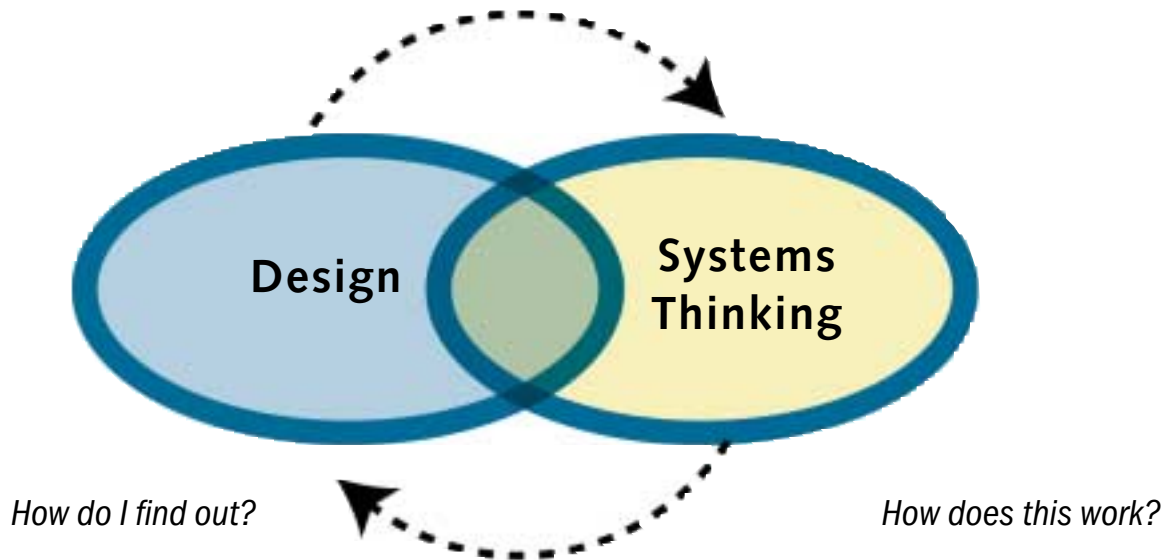
In other words, a systems thinking approach is the best way to present how things in the world really work in an interconnected, interdisciplinary way. Design is about what one does with this understanding for example, to devise courses of action that will replace existing things with better ones.

Curriculum Approaches

To help prepare students for a rapidly changing world, the State Board of Education adopted five workplace readiness standards to be integrated with the seven content areas. These standards define the skills that students need as they pursue college, careers, and adult responsibilities as citizens. The Cross-Content Workplace Readiness Standards include: 1) career planning and workplace

skills; 2) use of technology, information, and other tools; 3) critical thinking, decision making and problem solving; 4) self-management; and 5) safety principles.

Unlike the cumulative progress indicators for the other content areas, the workplace readiness indicators are not organized by grade-level clusters because, in addition to crossing all content areas, they also cross grade levels. Teachers and counselors should integrate these concepts into all programs in content-specific and developmentally appropriate ways. To strengthen the linkages between the content areas and cross-content workplace readiness, framework activities and scenarios include interdisciplinary and integrative approaches to workplace readiness.

H. Lynn Erickson makes the following observation about integrated curricula in *Stirring the Head, Heart, and Soul: Redefining Curriculum and Instruction*:

> Curriculum integration is the organization of content under a common, abstract concept such as interdependence or conflict. The goal of integrated curricula is to illuminate more clearly the concept under study in relation to a significant theme, problem or issue, through the application of higher-level thought processes as students analyze, synthesize, and generalize from information to knowledge.

Teachers will find that there are many stages of instruction leading to the integrated approach. Teachers are asked to take steps to move the instructional classroom toward integrative levels. The systems thinking method will help students comprehend complex realities and design will help them improve them.

This framework is designed to illustrate a path for the integration of cross-content workplace readiness standards. It is also designed to be usable within the constraints of the existing educational structure.

Figure 1.2

ILLUSTRATION OF APPROACHES

Stovepipe Disciplines

Interdisciplinary Approach

Integrated Approach
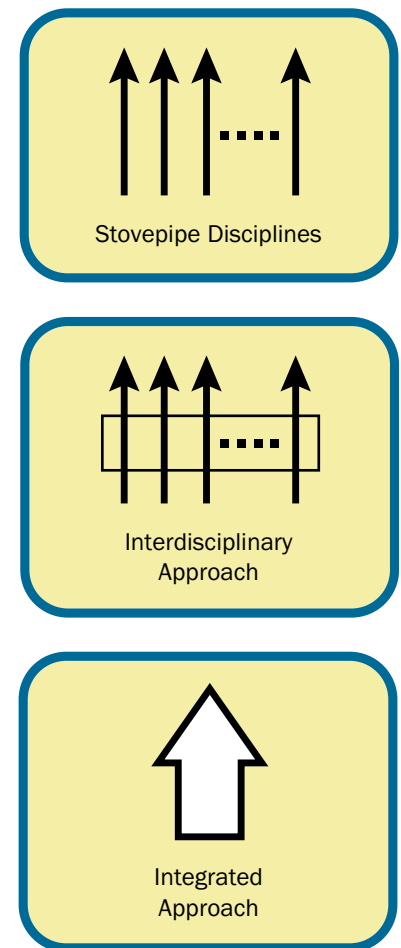
A Model For Cross-Content Workplace Readiness

Knowledge is increasing at an exponential rate. This poses a dilemma for an educational system that uses a model of discrete disciplines and a finite amount of "teaching" time. The key question is how to impart ever increasing knowledge over this finite amount of time. One solution is to move from the traditional approach in which the teacher imparts knowledge to a new approach in which the teacher is in the role of facilitator of learning. Table 1.1 compares the characteristics of classrooms in these two scenarios as defined by Jacqueline and Martin G. Brooks in *The Search of Understanding: The Case for Constructivist Classrooms* (1993).

Table 1.1

COMPARISON OF TEACHER ROLES

Teacher Imparts Knowledge	**Teacher Is a Facilitator of Learning**
• Curriculum is presented part to whole, with emphasis on basic skills	• Curriculum is presented whole to part with emphasis on big concepts
• Strict adherence to fixed curriculum is highly valued	• Pursuit of student questions is highly valued
• Curricular activities rely heavily on textbooks and workbooks	• Curricular activities rely heavily on primary sources of data and manipulative materials
• Students are viewed as "blank slates" onto which information is etched by the teacher	• Students are viewed as thinkers with emerging theories about the world
• Teachers generally behave in a didactic manner disseminating information to students	• Teachers generally behave in an interactive manner, mediating the environment for students
• Techers seek the correct answer to validate student learning	• Teachers seek the students' point of view in order to understand students' present conceptions for use in subsequent lessons
• Assessment of student learning is viewed as separate from teaching and occurs almost entirely through testing	• Assessment of student learning is interwoven with teaching and occurs through teacher observations of students at work and through student exhibitions and portfolios
• Students primarily work alone	• Students primarily work in groups

Table 1.2

SUMMATIVE AND FORMATIVE ASSESSMENT

Summative	Formative
• Educator-developed assessment	• Student-developed assessment
• Learning ends with assessment	• Assessment guides future learning
• Assessment used for judging/tracking	• Assessment is used for feedback
• Assumes a "bell curve" model	• Criterion referenced
• Uses "paper and pencil" tests	• Uses rubrics
• Focus on recall/recognition	• Iterative process
	• Portfolio/Performance-oriented

The following project illustrates how the aspects discussed above can be applied in classrooms today.

Pyramid Reconstruction: A Systems Thinking Project

The Pyramid Project can be scaled as a content-area activity, an interdisciplinary activity, or an integrative activity. Students may work individually, collaboratively, or cooperatively, or they may use a variety of approaches appropriate to the project tasks.

The primary goal of the Pyramid Project is to engage students in grades K to 12 in activities that emphasize problem solving, critical thinking, systems thinking, and communication processes. The teacher and students work together to define the problem. Examples of problems include the following:

- How can a heavy object be moved up an inclined plane?
- What aspects of the system in existence at the time enabled the Great Pyramids of Egypt to be built? Which aspects of that system are still in existence today?
- Develop alternative methods of building the pyramids within specified constraints, for example, limited human, natural, and economic resources and realistic distances for moving large stones.

Background

The Great Pyramids at Giza, built more than 4500 years ago, continue to impress engineers and technologists. These tombs are the most famous of the pyramids, but there are more than eighty other pyramids in Egypt. The largest of the three, the Great Pyramid of King Khufu, was built about 2550 B.C. At its peak, it was 481 feet tall and had a square base 756 feet on each side. Approximately 2,300,000 blocks of solid limestone, each weighing about 2.5 tons, were used in its construction.

The pyramids, and the building of them, served a critical societal purpose in ancient Egypt. Many scholars have offered theories on how the Egyptians accomplished construction of the pyramids. However, there is no definitive proof to substantiate their conjectures.

The ancient Egyptians were faced with many problems while building the pyramids at Giza. One of the challenges they faced was to find a way to move the heavy blocks of stone into position to build the pyramid. The largest pyramid at Giza is more than 450 feet high and required more than two million stones.

Regarding the form of labor, the theory that has gained credibility was that the Great Pyramids of Giza were built by "free" labor, rather than by slave labor. Workers willingly gave their time with the expectation of a better afterlife for themselves, as well as for the pharaohs. Other pyramids in other dynasties were most certainly built by slave labor.

The Egyptians needed to be quality workers. Clearly, their finished project is evidence of their ability to work both individually and in teams. The Egyptians understood a great deal about technology and practical problem solving. They were critical thinkers who knew how to make decisions. There was division of labor among the ancient Egyptian workers. For example, there were surveyors, stonecutters, rope pullers, engineers, architects, and designers.

The ancient Egyptians worked on the pyramids only three months of the year, when the Nile River overflowed. The annual overflowing of the Nile was critical for enriching the soil along its bank to provide nutrients for growing crops to feed the population. This annual event set the clock and pace for life in ancient Egypt.

Simulation is a practical educational tool that helps clarify issues in a problem. A common simulation model is a stock-and-flow diagram which translates any situation into visual or quantitative terms. Figure 1.3 is the representation of a simple stock-and-flow model for the labor and material resources needed to build a pyramid. The rate at which the pyramid can be built depends on the number of laborers, labor productivity, and the number of stone blocks available. Students can see the results of varying these parameters, and they can use such a model to discuss the effects of different labor poli-

Figure 1.3

SIMULATION OF LABOR AND MATERIAL RESOURCES NEEDED TO BUILD A PYRAMID OVER A PERIOD OF TIME
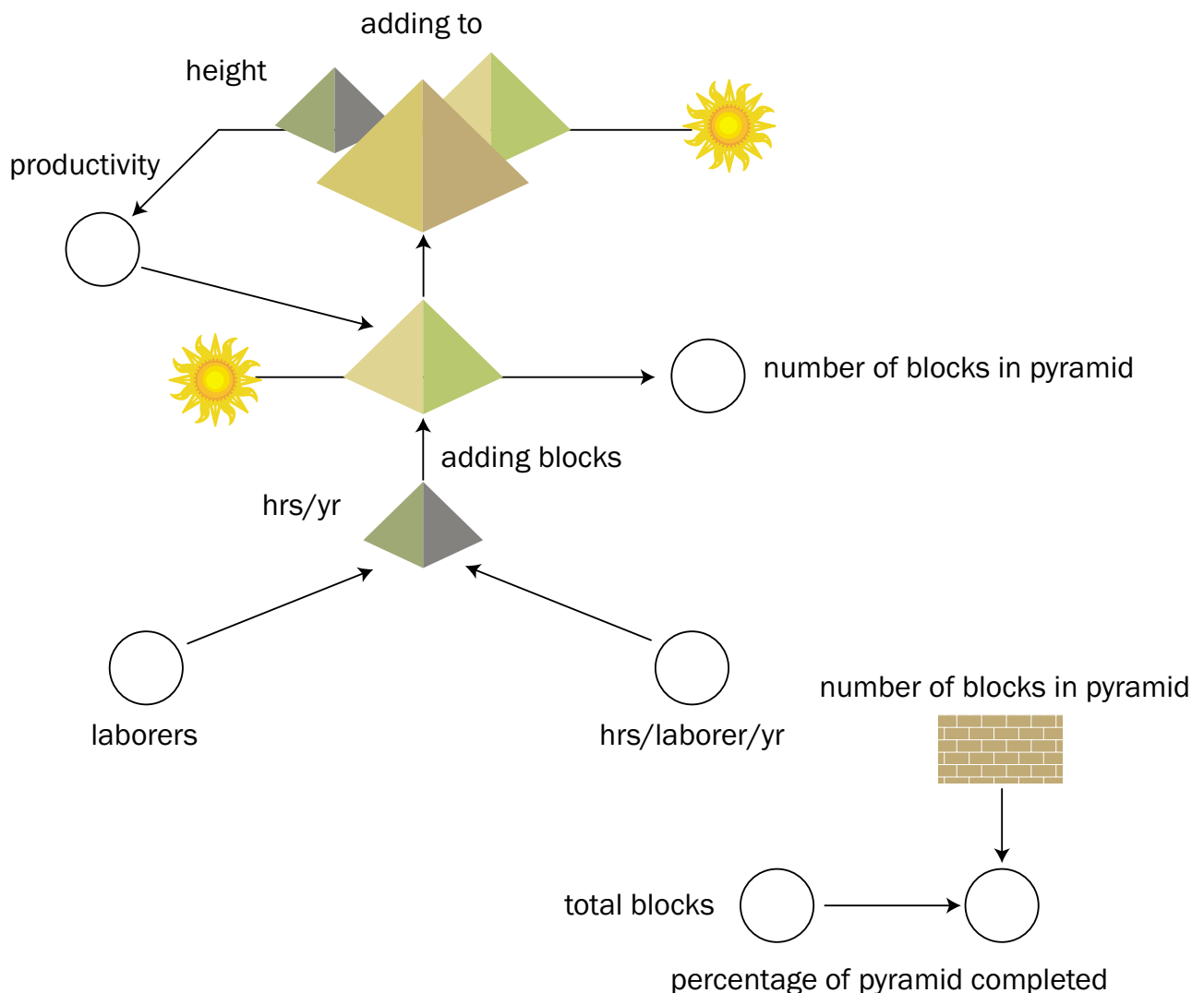
cies on completion of the pyramid. One policy to be assessed could be the enlistment of a workforce of free labor highly motivated to see that the pharaohs' place in the afterlife is secured, thereby securing their own places in the afterlife. Another policy to be assessed could be the use of slave labor, perhaps not so highly motivated.

Table 1.3 summarizes some ways in which the Pyramid Project can be used as a content-area activity, an interdisciplinary activity, or an integrated activity.

Table 1.3
INTERDISCIPLINARY AND INTEGRATED APPROACHES FOR THE PYRAMID PROJECT

Content Area	Interdisciplinary	Integrated
• The problem is to size the amount of labor and the time needed to build the Great Pyramid at Giza, assuming that work is performed for only three months each year. • Contrast the problem with the amount of labor and time needed to build the Great Pyramid using the processes, tools, and technologies available in modern-day America.	• Build on the content-area problem for the amount of labor and time needed to build the Great Pyramid at Giza: develop a plan to recruit workers; plan a diet for the workers and estimate how much food would be required to meet their needs. • Build on the content-area contrast with modern America: propose a plan to recruit workers; estimate how much food would be required; estimate how much energy would be needed to operate tools.	• Build on the interdisciplinary problem by proposing an alternative "year-round worker" scenario and the impact of this alternative on the growing of food. • Build on the interdisciplinary problem by contrasting the effort with the number of workers in the construction industry and farming in modern-day America; project the employment trends of the two groups.

Source: Adapted from Derek Hitchins in a 1995 presentation on "Systems Engineering the Pyramids."